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GRAVEL AGGREGATE IN MISSISSIPPI - ITS ORIGIN AND DISTRIBUTION

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INTRODUCTION

Gravel aggregate and sand constitute the most important naturally occurring building materials in Mississippi and after oil and gas are the greatest income-producing mineral products in the state. Aggregate underlies significant areas of the state. However, some regions have no local sources. These include large population centers, such as Jackson and the Gulf Coast, and a north-south belt between the loess belt and the Tombigbee River. Gravel is a high volume - low cost resource; therefore, cost of haulage by trucks becomes a significant economic factor and cost of railroad transportation is nearly prohibitive.

In the near absence of suitable rocks to crush and of dimension stone, Mississippi, for more than a century, has utilized gravel aggregate for road construction, concrete aggregate, and other uses.

Gravel is being mined commercially in three regions of the state (Figure 1): (1) several areas in northeastern Mississippi associated with fluvial deposits of the Tombigbee River and Tennessee River, and basal Cretaceous gravels; (2) a narrow belt beneath the Loess Hills that extends from Memphis, Tennessee, to south of Natchez, Mississippi; and (3) a wide east-west belt in southern Mississippi.

Although locally more than 25 meters thick, the deposits seldom are more than 5-6 meters thick. They tend to be discontinuous and the tenor highly variable. The ratio of gravel thickness to overburden in all areas is highly variable and depends on several factors, including supply of gravel available to area, thickness of alluvium (related to the stream size), subsequent erosion history, and, in the case of the loess belt, thickness of loess. Alluvium in the Tombigbee River system averages about 10 meters thick and, near their source, gravel-bearing sands may be 4 meters thick. Brown's (1947, p. 54) studies of borings in the Mississippi River Valley alluvium of the "Delta" indicate that the average thickness of the lower sand and gravel is 29 meters and the "upper loam and clay" 8 meters. It should be noted that these are averages.

Chert is the principal mineral in Mississippi gravel, which contains minor amounts of quartz and quartzite. Particle size varies from bed to bed within a pit, and from pit to pit, but as a general rule, the average particle size is less than 2 cm. Individual clasts up to 30-60 cm in length are not uncommon, especially in the loess belt. The gravel is, generally, in a matrix of quartz sand and, except within lenses, is rarely more than half the deposit. Although highly variable in roundness and shape, clasts tend to be sub-rounded and the shapes tend to be rollers and blades. Light or incompetent (unsound) and reactive clasts are a problem in many areas (Figures 2 and 3).

For the most part, the deposits are fluvial in origin, and range in age from Cretaceous to Recent. In general, the deposits are stratified with a basal, coarse, sandy gravel that grades upward into point bar sands and then into back-swamp silts and clays, a sequence that is typical of meandering stream deposits.

Modern streams are still reworking, transporting and depositing the gravels. The aggregate has been transported from external areas into Mississippi by large streams. Gravel abundance, like its average particle size, decreases downstream from the source area. Multiple terrace deposits are associated with the Tennessee and Tombigbee river systems, and both systems have derived aggregates from basal Cretaceous gravels.

Gravel operations in Mississippi fall into two general categories - those above and those below the water table. Where the gravel is below the water table, as in an alluvial valley, or in a river, use of a dredge or dragline is the preferred recovery method, and, generally, the gravels are washed and sized on screens as part of the operation. In larger deposits above the water table, excavation equipment such as draglines may be used, but in smaller pits the basic equipment in use is the "back-hoe." Larger operations may wash and screen the sand and gravel for specific uses, but access to water is a problem.

SOURCE OF GRAVEL AGGREGATE

Gravel aggregate in Mississippi has been derived largely from weathered Mesozoic, Paleozoic and older rocks adjacent to, and even distant to this region. The gravels have a complex genesis and transportation history, and have been transported long distances from their source area.

Mineralogic suites have been complicated by introduction of materials from exotic source areas. Basically, however, three provenance areas can be recognized on the basis of mineral suites (Figure 1): (1) Tennessee River, predominantly chert; (2) a northern source area that introduces jasper and quartz; and (3) a western source area including Missouri and Arkansas.

Tennessee River Provenance Deposits

The primary sources of aggregate are basal Cretaceous gravels in Alabama, Mississippi, and Tennessee, but the ultimate sources are deeply weathered, siliceous Paleozoic rocks that crop out along the western Highland Rim in Tennessee, northwestern Alabama, and in northeastern Mississippi where they are buried. The porous chert gravels originated when siliceous carbonates of the Mississippian Ft. Payne and Tuscumbia formations were subjected to intense weathering during Cretaceous times. Leaching reduced the rocks in the Mississippi, Tennessee, and Alabama areas to bedded porcellaneous cherts, with high microporosities, and siliceous rubble and kaolinitic clay. An admixture of quartzite, quartz, and sandstone pebbles and quartz sand was probably derived from Pennsylvanian rocks in northern Alabama and adjacent Tennessee. Quartzite pebbles in the modern Tennessee River probably have been derived from the Blue Ridge metamorphic belt.

In late Cretaceous times, two stream systems were located in northeastern Mississippi and northwestern Alabama. One, a system of southeast-flowing streams along the Pascola Arch (Marcher and Stearns, 1962) in western Tennessee and northern Mississippi cut deep valleys into the chert-bearing formations and transported large amounts of chert gravel to northwestern Alabama and northeastern Mississippi. Second, in northern Alabama, a major southwest-flowing stream system contributed quartz sand and quartzite pebbles as well as chert. In late Cenomanian and Turonian times, Cretaceous seas overlapped and buried the gravels in these fluvial systems.

Subsequent uplift and erosion in late Paleogene and Neogene times uncovered the Cretaceous gravels in the Tennessee and Tombigbee river drainages. During the evolution of those respective drainage systems, a series of widespread, thick, gravel-bearing terrace deposits were laid down on the soft coastal plain sediments. Although only small areas of Tennessee River terrace deposits are present in northeastern Mississippi, large areas of western Tennessee and western Kentucky are underlain by these gravels.

Northern Provenance Gravels

In western Kentucky a flood of chert gravel from the Tennessee River joined mineralogically different gravels in a major drainage system probably ancestral to the Mississippi River. The northern part of the ancestral drainage system, to which the Tennessee River was tributary, has been obliterated by Pleistocene glaciation, and only remnants of the southern part of the system are preserved beneath the loess in Kentucky, Tennessee and Mississippi. Gravels beneath the loess at Memphis, Tennessee, and at numerous sites in Mississippi, including Vicksburg and Natchez, are parts of that system.

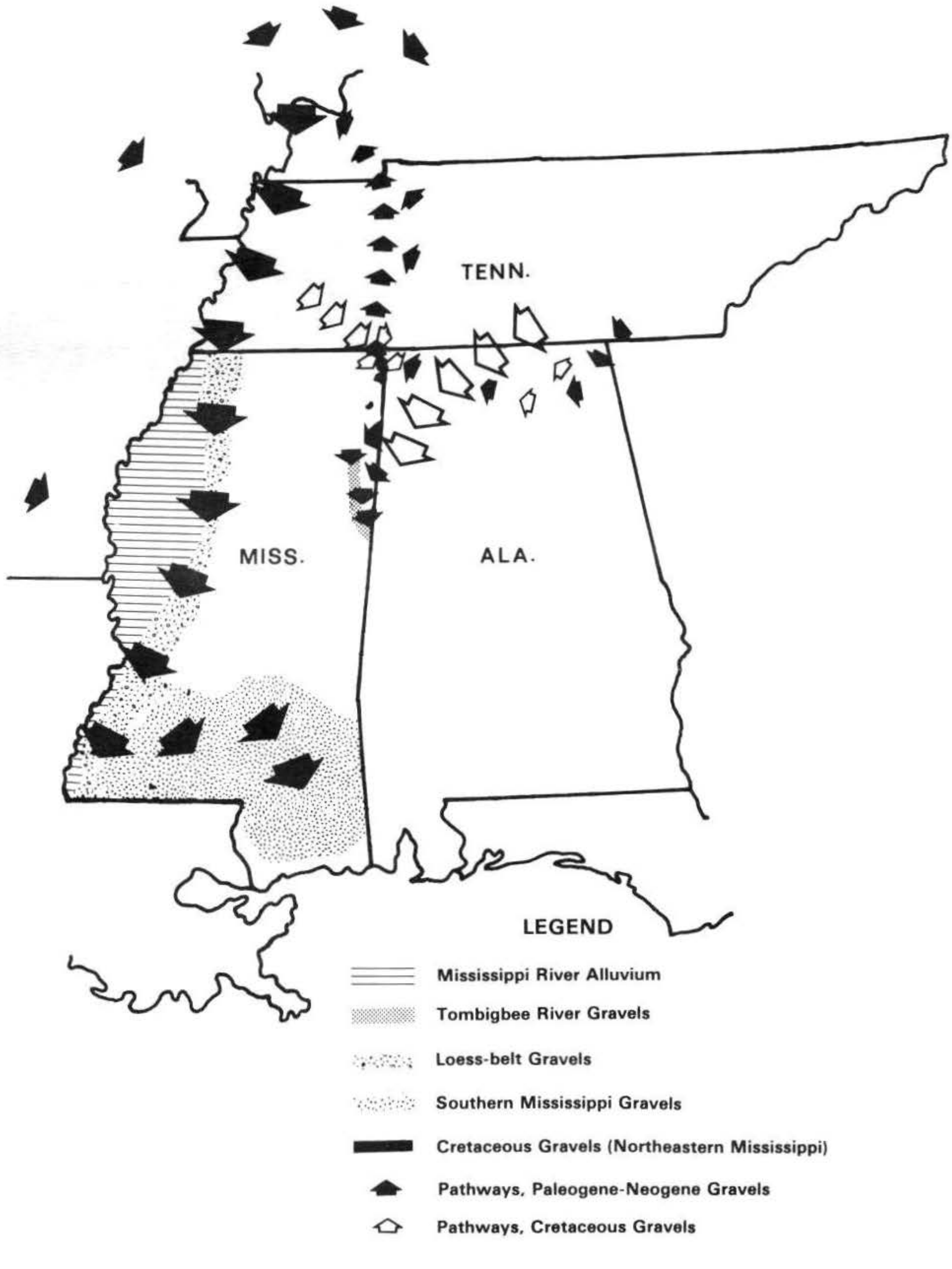
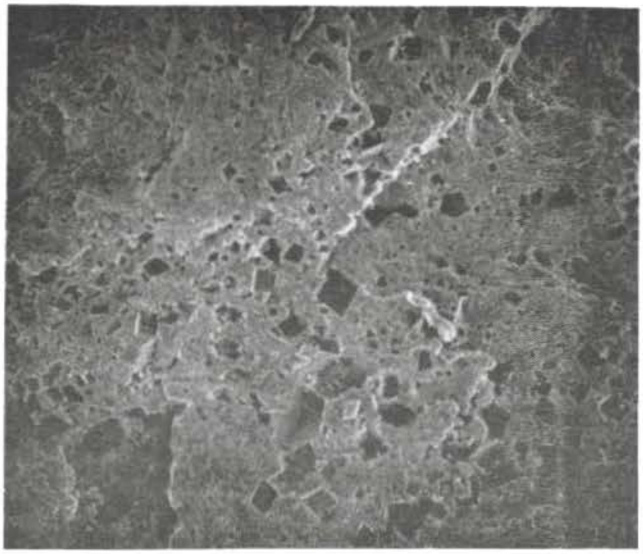


Figure 1. Map showing gravel areas in Mississippi and travel pathways. Open arrows indicate pathways of Cretaceous gravels and solid arrows are Paleogene-Neogene pathways.



10 μ

Figure 2. Scanning electron micrograph of a porous chert clast from the Tuscaloosa in Tishomingo County, Mississippi. The unusually high porosity in this specimen, due to the numerous rhombohedral dolocasts, would be an important factor in the soundness of the aggregate.

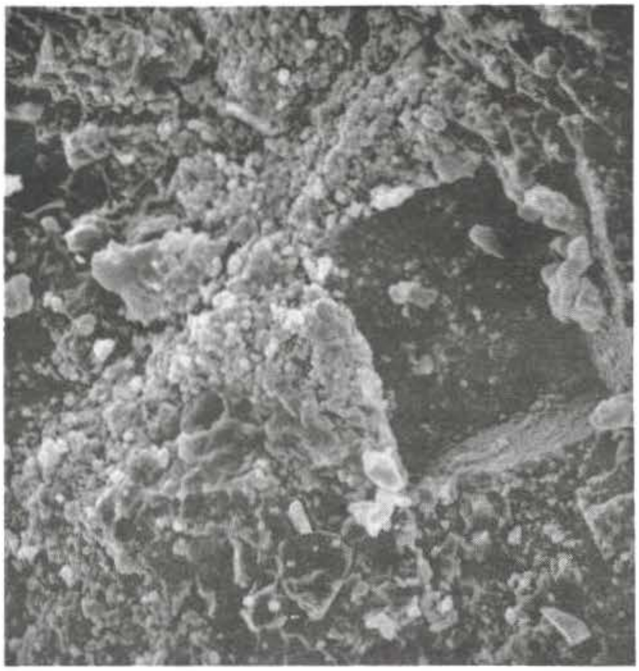


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Figure 3. Scanning electron micrograph of a typical chert clast from Tombigbee River terrace deposits in northeastern Lowndes County, Mississippi. At high magnification the texture that gives rise to high porosities and low specific gravities is apparent. Euhedral quartz crystals line fractures, but the mass is composed of poorly sheeted aggregates of rounded to botryoidal quartz resembling very small lepispheres.

The great diversity of rock types in the clasts of this drainage, especially the rare pieces of taconite, suggests a source area far to the north in the Precambrian shield. The suite, to which the monotonous Tennessee cherts were added, includes oolitic and fossiliferous cherts, agates, jasper, chalcedony, flint, quartz, and quartzite. Quartz-lined geodes are not uncommon. Igneous and metamorphic rock clasts derived from Pleistocene glacial deposits are found in the modern Mississippi River sediments, but none have been reported from the terrace deposits (W.W. Olive, personal communication).

Western Provenance

Mineralogic evidence indicates western source areas. Also, rare chert pebbles bearing fossil fusilinids have been found in gravel pits in southern Mississippi. Since Carboniferous fusilinids are commonly found in the central western states, this indicates that there were western tributaries to the ancestral Mississippi River similar to the White, Arkansas, and Red rivers.

DISTRIBUTION OF GRAVEL IN MISSISSIPPI

Gravel aggregate occurs in commercial deposits in four regions of Mississippi (see Figure 1): (1) northeastern Mississippi; (2) loess-belt gravels; (3) southern Mississippi; and (4) Mississippi "Delta."

Northeastern Mississippi

The occurrence of gravel aggregate in this region is directly related to the outcrop of basal Cretaceous gravels, and to terrace deposits and alluvium along the Tennessee and Tombigbee river systems that contain reworked Cretaceous gravels. In the case of the latter stream system, commercial gravel deposits are closely related to two west-flowing, gravel-bearing tributaries, Bull Mountain Creek and Buttahatchie River.

Iuka-Belmont-Tremont Area

Commercial aggregate in this area is associated for the most part with basal gravels of late Cretaceous age that are either in the Gordo Formation or its lithic (not time) equivalents. North and east of Iuka, Mississippi, in Indian Creek and Bear Creek drainages, there are thick deposits of chert gravel that have a long history of use. Near the Mississippi-Alabama state line aggregate thicknesses of the gravel may reach more than 30 meters. A wide range of sizes from pebbles to

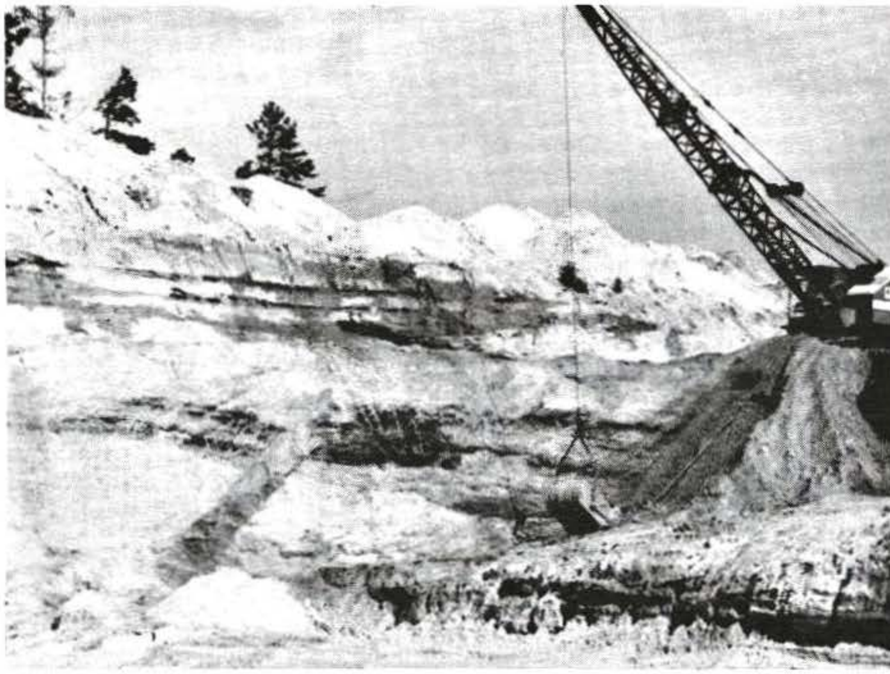

Figure 4. Gravel pit in Gordo Formation of Tuscaloosa Group in northeastern Itawamba County, Mississippi. Nearly twenty meters of chert gravel in quartz sand is exposed in the pit. Tuscaloosa gravels are the chief source of aggregate in the Tombigbee and Tennessee river systems in Mississippi and an important source for those beneath the loess and in southern Mississippi.

Figure 5. Typical small pit in the first terrace above the Tombigbee River flood plain in southern Monroe County, Mississippi. About three meters of alluvial chert gravel and sand overlain by 2-3 meters of backswamp silts and clays.

cobbles and a lack of quartz characterize the gravels. Chert sand and local lenses of kaolinitic clay are minor constituents.

West of Belmont, in southern Tishomingo County, Mississippi, in the Rosebud and Rock Creek valleys, up to 12 meters of basal Cretaceous aggregate is present. The upper meter or so of the gravel is identical lithologically to that in the Iuka area, but the lower gravels are distinctly different. In the latter chert clasts are, in general, finer, they are supported in a quartz sand matrix, and there are rare quartzite pebbles. The lower gravels are equivalent to the Gordo Formation. Cretaceous gravels are absent a short distance to the west and northwest.

Thick beds of gravel and sand in the basal Gordo Formation crop out in the valley walls of Bull Mountain Creek northeast of Tremont, Mississippi (Figure 4). In this area more than 18 meters of chert gravel in quartz sand matrix is exposed in the pit faces, and drilling confirms at least another 8 meters beneath the pit. Field studies suggest there may be as much as 30 meters total thickness of gravel and sand. Chert dominates the gravel but there is 3-4 percent quartzite and quartz. About one-third of the deposit is gravel and most of that is less than 2.5 cm in diameter. Large gravel pits with washing and screening operations are working in this area.

Tennessee River Terraces

The uplands on either side of Yellow Creek, just before it enters the Tennessee River, are underlain by remnants of old Tennessee River terrace deposits. Most are at elevations above 152 meters (500 feet). The gravel, reworked from basal Cretaceous gravels, described above, is leached and stained with iron oxides and locally may have thin beds of ferruginous cement. Locally the gravels may be 8-10 meters thick in the base of the terrace deposits, which may reach total thicknesses of more than 15 meters. More extensive deposits of these gravels occur in Tennessee, where they are widely mined.

Bull Mountain Creek-Tombigbee River in the Amory Area

Gravel in this drainage system has been reworked from the Cretaceous in Alabama and the Tremont, Mississippi, area, and transported into the Tombigbee drainage at Smithville, Mississippi, by Bull Mountain Creek. No significant terrace deposits are associated with Bull Mountain Creek, but there are a few dredging operations in the flood plain. Large, gravel-bearing terrace deposits occur on the east valley wall of the Tombigbee River below Smithville, Mississippi, and the lower two terraces are very gravelly. Most of the mining activity is, and has taken place, in the modern alluvium and channel of the Tombigbee River, especially in the vicinity of Amory, Mississippi. Gravel in the alluvium tends to be cleaner than that in the terraces, but, like in the terraces, most has a patina of iron oxide.

The southern limit of commercial gravel operations is a short distance south of Amory, Mississippi. Although gravel does occur in the alluvium and in the terrace deposits beyond that point it is, for the most part, sparse.

The Columbus Area

This is an old mining area; the most important source of gravel aggregate is the Buttahatchie River, with the Luxapallila as a secondary source. Important aggregate deposits occur at the confluence of the Buttahatchie with the Tombigbee River in northern Lowndes County, Mississippi, and this is the region most intensely exploited. A second area, at the confluence of the Luxapallila south of Columbus, Mississippi, has been an area of great activity in the past. Numerous terrace deposits are present on the east valley wall of the Tombigbee River and all have been the source of gravel (Figure 5).

The largest gravel operations, at present, are in the flood plains of Buttahatchie and Tombigbee rivers northwest of Columbus, Mississippi. Gravel and sand deposits as thick as 10 meters have been reported from this area, but as a rule they are less than half that thick.

The gravels thin rapidly downstream, but south of the Luxapallila the gravels thicken for a few miles. The abundance of gravel in the terrace deposits parallels that in the alluvium.

Loess-Belt Gravels

Loess on the eastern edge of the Mississippi River valley is underlain in many places by pre-loess gravel, sands and clays that are the dissected remnants of a large fluvial system probably ancestral to the modern Mississippi River system. Mellen (1959, p. 31) referred to these gravels as "the Citronelle gravel belt;" Snowden and Priddy (1968, p. 127) describe them as "Citronelle," noting the problems surrounding the name; and they are called "Pre-loess terrace deposits" by Bicker (1966, p. 30) in Claiborne County.

The gravel deposits vary considerably in thickness and in gravel content. In Panola County the deposits range from less than a meter to more than 15 meters in thickness. In Claiborne County Bicker (1966, p. 48) noted that the thickness of the gravel deposits ranges "from a few feet to as much as 76 feet."

Numerous kinds of chert are present in the gravels, including fossiliferous chert, agate, jasper, flint, chalcedony, and small amounts of quartz and quartzite. Particle size distributions vary from area to area and pit to pit, even from bed to bed, but in most areas probably average 2 cm or less. Locally, there are cobbles. In Panola County the gravel appears to thin and become finer grained to the east.

Gravel has been mined from this belt for many years.

Southern Belt

There extends eastward from the loess belt, south of the latitude of southern Hinds County, to Alabama, a broad belt in which gravel is mined. The gravels occur in the basal beds of dissected high-level terrace deposits and in terrace deposits and alluvium of major streams.

The high-level terrace deposits, which cap the highest elevations between major stream divides and dip gently toward the Gulf of Mexico, have been highly dissected by modern streams. The Geologic Map of Mississippi (Bicker, 1969) shows their distribution. Their origin and age, still the subject of debate, is beyond the scope of this paper. The commonly accepted term for these sediments is the Citronelle Formation (Matson, 1916; Doering, 1956; Mellen, 1959). Doering (1956, p. 1852) described the Citronelle in Mississippi as having a "maximum surface thickness of 150 feet, 60-70 feet of basal gravelly sand, 60 feet of slightly clayey sand, and a top member of 20-30 feet of fine clayey sand and sandy clay."

Citronelle gravel, similar mineralogically to that in the loess belt, is common and widely mined in southern Mississippi. Foster (1941, p. 31) reported nearly 30 meters of sand and gravel in the Citronelle of Forrest County. However, the gravel decreases markedly in abundance and size to the east and north in Jasper and Wayne counties and to the southeast in George County.

Large areas of the Citronelle deposits in the major drainage basins of the Homochitto, Pearl, and Pascagoula rivers have been eroded away and the gravels and sands reworked into terrace deposits associated with those streams. Gravel in the modern alluvium and that presently being carried by the stream systems has been reworked from the stream-related terrace deposits and the Citronelle. Foster (1941, p. 29) reported that the alluvium in Forrest County is "far richer" in gravel than the terrace deposits.

Mississippi "Delta"

The region shown on the location map (Figure 1) is underlain by the alluvial deposits of the Mississippi River and its tributary systems. Though called the "Delta" by local inhabitants, it is alluvial valley fill. Available data suggest that it has large potential gravel resources, but access to the gravel is difficult and it underlies some of the most fertile land in the United States. Numerous boreholes by the U.S. Corps of Engineers and others have proved the presence of the gravel.

Brown (1947, p. 54) summarized the occurrence of the gravels as being below clays, loams, and silts that range up to 26 meters in thickness. Based on numerous reports of water well drillers and the Mississippi River Commission, the thickness of the underlying sand and gravel ranges from less than 3 meters to more than 60 meters. The thickest alluvium parallels the Loess Hills.

Brown noted (1947, p. 54) that there are two suites of gravel in the base of the alluvium: gravel and sand in the "western and southern parts of the plain are composed mostly of pebbles and grains of brown chert, quartz, quartzite, fine-grained igneous and metamorphic rocks, granite, gneiss, and diorite; the pebbles and grains under a part of the northeastern plain are composed dominantly of brown chert, quartzite, sandstone, and limestone."

ACKNOWLEDGMENTS

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LATE NEOGENE STRATIGRAPHIC PROBLEMS IN COASTAL MISSISSIPPI AND ALABAMA

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INTRODUCTION

The lack of proper definition and precise dating of a thick, mostly regressive, clastic sequence beneath the Pleistocene coastal plain deposits and the late Pliocene Citronelle Formation inland remains a stratigraphic quandary in southern Mississippi and adjacent Alabama. These deposits, predominantly of fresh-water origin, to a lesser extent brackish, have been named the "Pliocene Graham Ferry formation" in Mississippi (Brown and others, 1944, p. 45-54), and "Ecor Rouge" and "Miocene (-Pliocene) coarse clastics" in Alabama and the western Florida Panhandle (Marsh, 1966; Isphording, 1983; Raymond, 1985). A thickness of 975 feet at Gulfport was cited by Brown and others (1944).

Even though the deposits included in the "Graham Ferry" are lithologically and paleontologically not clearly distinguishable from the underlying Miocene Pascagoula Formation and no major unconformity has yet been found to separate them from the Pascagoula, the term persists in the local literature. Thus, Colson and Boswell (1985) claimed that the "Graham Ferry" contains 60 percent of the industrial and municipal ground-water supply of the Mississippi Gulf Coast. In the local ground-water literature, aquifer lenses and horizons have been artificially chosen as the base of this "formation." During the past decade, core samples from scores of coastal and offshore drillholes, representing thousands of linear feet and analyzed at 5- or 10-foot intervals, have been studied in order to achieve a better definition of the Late Neogene and Quaternary stratigraphic units in the three-state area. Samples from 17 offshore rotary drillholes (Figure 1a, b), donated by oil companies, provided hitherto unavailable insight into the shallow offshore stratigraphy.

Unfortunately, plant pollen in this part of the country cannot be used in subdividing this predominantly non-marine Neogene sequence (R.Z. Poore, U.S. Geological Survey, written communication, 1985). Attention thus is focused on finding age-diagnostic planktonic fossils. A very few, thin, fully marine beds contain them, but the more common, reduced salinity deposits do not. The latter contain faunas dominated by *Ammonia beccarii, Elphidium*, and *Nonion*. Even if planktonic foraminifers that define a sufficiently narrow time interval are present, similarly suitable nannoplankton assemblages do not necessarily accompany them. When available, nannoplankton taxa tend to range over too wide a late Neogene stratigraphic interval to be particularly useful. This applies also to nannoplankton east of Wynnehaven, Florida, including the Apalachicola Embayment (Akers, 1972, p. 14-30). Still another problem is natural or artificial sample contamination. Marine facies of the late Pleistocene Biloxi Formation (Otvos, 1985) contain several reworked middle Miocene and younger Neogene planktonic foraminifers at shallow depths in the Pascagoula Chevron Refinery and in Block 72, Mississippi Sound, including *Globigerinoides subquadratus, Globorotalia praemenardii, and Globigerina praebulloides* (Figure 2). Cretaceous nannoplankton were reported from Pleistocene marine beds in Block 115 and from late Neogene sediments in Block 1006.

While the offshore drillholes provided much information on the Quaternary units with great lateral and vertical variability, only two of them displayed thin marine intervals with age-diagnostic Neogene fossils. The uppermost Neogene sequence consists of fluvial-deltaic sands and clays with local brackish water lenses, within which the presence of consistent time horizons or unconformities could not be established. The situation was identical in about 10 to 12 coastal coreholes that penetrated 100-180 feet into the upper Neogene, drilled recently in Gulfport Harbor, Point aux Chenes, and Chevron Refinery, Mississippi, and in Alabama and the western Florida Panhandle.

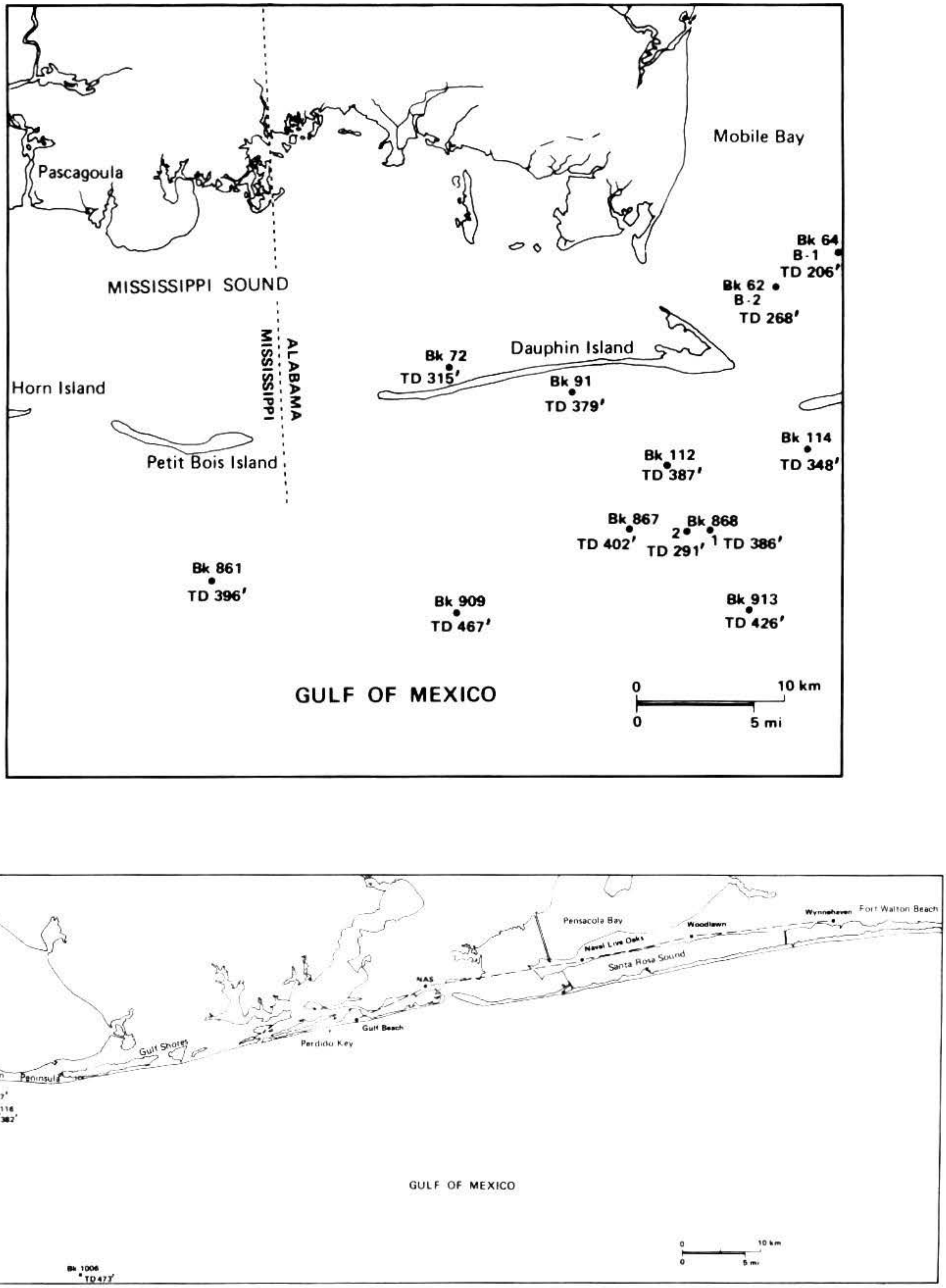

Figure 1a, b. Locations of Mobile area offshore drillholes and western Florida Panhandle coreholes.

DATING THE LATE NEOGENE

Definition of the upper boundary of the Pascagoula Formation in southern Mississippi, first described by Johnson (1893), would be the first step in delineating the overlying unit. This upper boundary has been defined by the shallowest appearance of two bivalves, the diminutive *Rangia (Miorangia) microjohnsoni* Gardner and *R. (Miorangia) johnsoni* Dall (Gardner, 1940). The faunizone is believed to range from the mid-Miocene through the "uppermost" Miocene (Ellisor, 1940; Akers and Drooger, 1957; Raymond, 1985). Brown and others (1944) assigned both the Hattiesburg (tentatively) and the Pascagoula formations to the middle Miocene, correlating the entire *Rangia johnsoni* faunizone with the Pascagoula. Near the mainland shore the "first appearance" of the bivalves was reported at about 680 feet minimum depth (Geological Survey of Alabama log files), and in an adjacent Jackson County, Mississippi, area at 980 feet (Harvey and others, 1965). The discontinuous nature of the brackish lenses that include the bivalves and the uneven quality of drill data in the coastal area may account for such discrepancies. If present at all in the paralic sequence, the Miocene-Pliocene boundary probably occurs higher than this sketchy record would suggest. In Block 115, a *Globigerina praebulloides*-bearing lens occurs well downdip, at only 340.0-360.5 feet below sea level, within a dominantly fluvial sequence. This species was accompanied by two others *(Globorotalia pseudomiocenica* and *G. obesa)* that range into the Pliocene and Quaternary. The lens also included the nannoplankton species *Sphenolithus abies, S. neoabies, Reticulofenestra minutula, Discoaster brouweri, D. variabilis* and *D. pentaradiatus* of late Miocene to Pliocene age.

With the exception of the Perdido Key Pliocene lens, the only presently identifiable Pliocene sediments in the entire Alabama-Mississippi subsurface are two clay and mud lenses between 373.5-454.0 feet in Mobile Area Block 1006 (Figure 2). *Globigerina riveroae* (Upper Pliocene planktonic foram zones N 18 (upper part) and N 19) was the most age-diagnostic fossil. In addition, *Globigerina nepenthes, G. venezuelana, Globigerinoides extremus, G. obliquus, Globorotalia dutertrei, G. miocenica, G. obesa, Globigerinita naparimaensis* and other planktonic forams were also present. The following nannoplankton species were also encountered: at 373.5-375.0 feet, *Helicosphaera sellii* (Pliocene-Pleistocene); between 452.5-454.0 feet, the upper Miocene-Pliocene *Reticulofenestra pseudoumbilica* and *Discoaster surculus;* and the Pliocene-lower Pleistocene *Pseudoemiliania lacunosa.*

Except for the Perdido Key area (Alabama-Florida) of Gulf Beach and the Pensacola Naval Air Station (NAS in Figure 1b), no datable Pliocene units have been encountered under the mainland shore between Wynnehaven, Florida, and Louisiana. The Gulf Beach marine lens between 125 and 130 feet (about 113-118 feet below sea level) (Otvos, 1985, p. 6-7) contained *Globigerina riveroae, G. nepenthes, Pulleniatina praecursor* and *Globorotalia plesiotumida* (Zones N 19-20) and ostracodes *Puriana mesocostalis* and *Malzella devexa.* In the NAS corehole, upper Pliocene ostracodes *Puriana mesocostalis* and *Loxoconcha edentonensis* occurred in a brackish-to-marine interval at 100-133 feet (85-118 feet subsea). Many of the earlier noted nannoplankton species were found also in the Gulf Beach lens: *Reticulofenestra minutula, R. pseudoumbilica, Discoaster brouweri, D. variabilis, Sphenolithus abies* and *S. neoabies,* as well as *Helicosphaera kemptneri, Coccolithus pelagicus, Thoracosphaera heimi* and *Gephyrocapsa* sp. The typical Jackson Bluff bivalve, *Nuculana trochilia,* was also present at Gulf Beach, another indication of the equivalence of this lens with the Pliocene Jackson Bluff Formation of mostly mid-to-inner shelf depositional facies, recently redated, redefined and described in detail

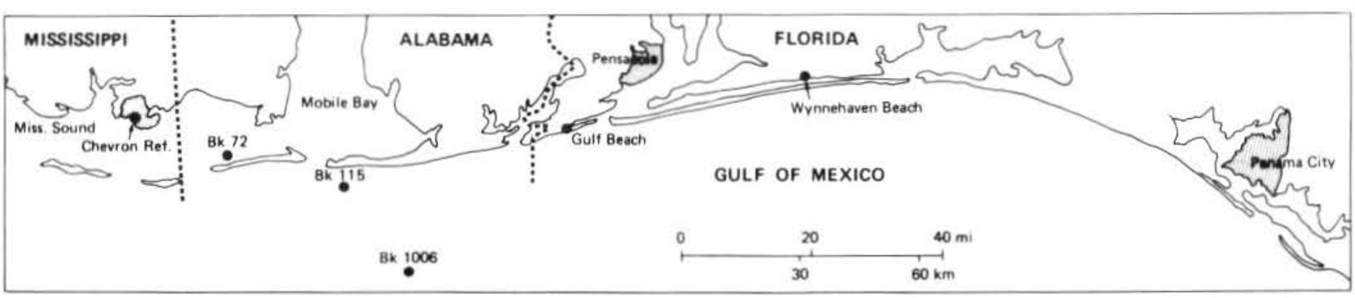

Figure 2. Locations of important mainland and nearshore drillholes noted in text.

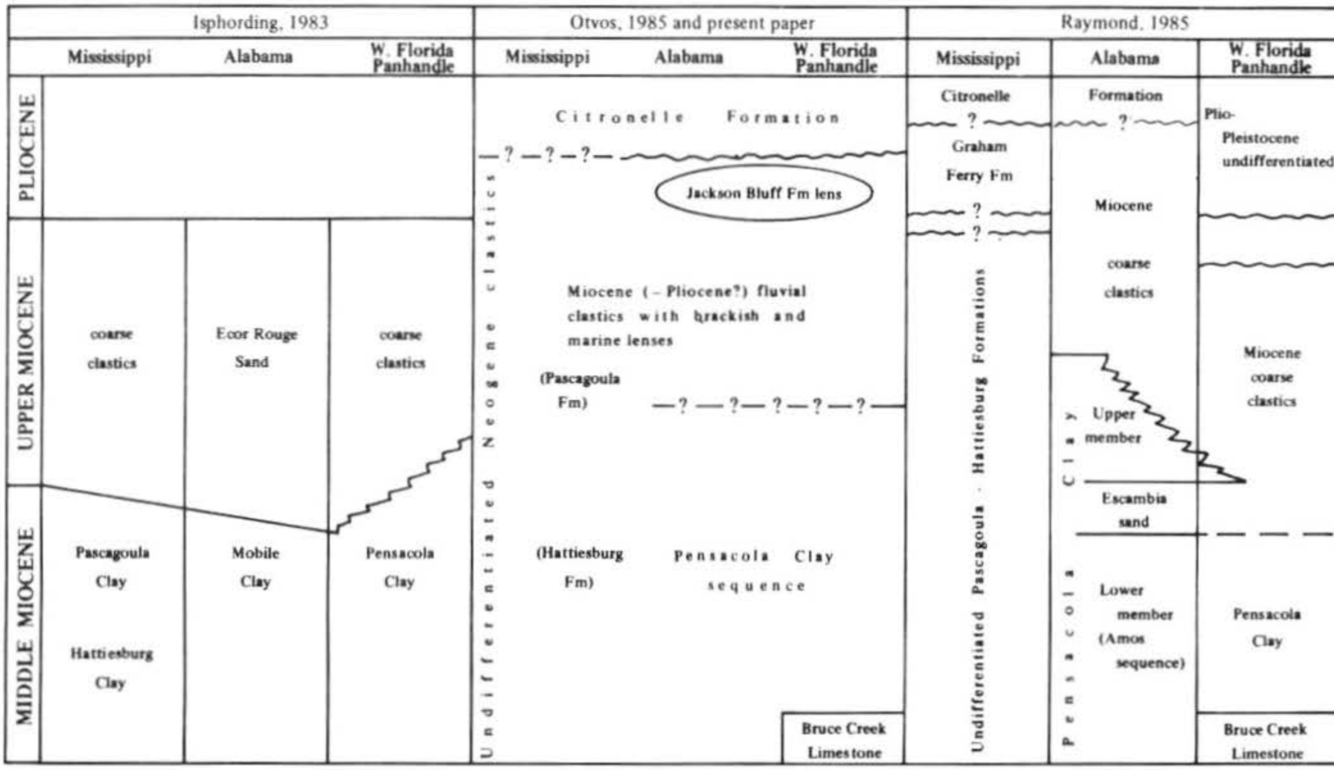

Figure 3. Pre-Citronelle late Neogene stratigraphy, northeastern Gulf coastal region.

in the eastern and central Florida Panhandle area by Huddlestun (1984) and Schmidt (1984), following Akers (1972). Late Miocene to middle Pliocene nannoplankton and late Miocene and early Pliocene ostracodes found with this fauna may have been reworked into it. The shallow position of this large lens suggests that the top portion of pre-Citronelle late Neogene paralic sediments in southern Mississippi and Alabama may also be of this age.

Collection of the rare molluscan fossils from outcrops of the uppermost part of the paralic sequence in the southern Mississippi area, if it is proven to be above the *Rangia johnsoni-microjohnsoni* faunizone, may yet lead to confirmation of a Pliocene age for the highest units. Brown and others (1944) reported casts and molds of "*Barnea costata* and *Pecten (Plagioctenium) irradians* Lamarck?" from "Graham Ferry" exposures. According to T.R. Waller (written communication, 1986), identification of *Cyrtopleura* (earlier: "*Barnea*") at species level from a mold is possible if the mold shows the exterior sculpture and form. *Cyrtopleura costata* has been reported in the Caloosahatchee (Florida) and Waccamaw (Carolina coast) formations, dated as uppermost Pliocene to lower Pleistocene. Thus, it would be highly significant if its presence could be confirmed in Mississippi outcrops. *Argopecten irradians* (the current taxonomic name of the other reported species) according to Waller is not known from pre-Pleistocene strata. A Hemphillian (upper Miocene to lower Pliocene) vertebrate fauna, containing land and fresh-water taxa in northern Mobile County, Alabama, (Isphording and Lamb, 1971) and found in the upper part of the late Neogene paralic sequence has not provided an exclusively Pliocene age yet.

Based on the fact that the Citronelle in the central Florida Panhandle overlies the middle-upper Pliocene Jackson Bluff Formation (Akers, 1972), the very late Pliocene (-very early preglacial Pleistocene?) age of the Citronelle may also be assumed in southern Mississippi and Alabama.

RECOMMENDATIONS

Until new geological methods and additional findings radically change our knowledge, formation boundaries should not be drawn within the southern Mississippi-Alabama upper Neogene paralic sequence. The term "Undifferentiated Neogene clastics" would be far more appropriate to use than "Graham Ferry" (Figure 3). In many sections of the sequence, in the absence of time-diagnostic fossil evidence there is no need even for the use of the Pascagoula and Hattiesburg formation designations. The thorough and diligent search for fossil and other stratigraphic evidence in the paralic sequence must continue.

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A HISTORY AND METHODOLOGY OF WASTE DISPOSAL SITE EVALUATIONS BY THE MISSISSIPPI BUREAU OF GEOLOGY

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The Mississippi Bureau of Geology has been involved in the geohydrologic evaluation of proposed and existing waste disposal sites since 1972. These evaluations are done in order for the Bureau to make recommendations, to the agency responsible for permitting these facilities, as to the suitability of a given site with respect to the geohydrologic conditions present. Currently, the Mississippi Department of Natural Resources, Bureau of Pollution Control, issues these permits. The main considerations in these investigations are the contamination of ground water through leachate migration or contamination of surface water due to flooding or normal surface drainage. As of November 1986, the Bureau has participated in the evaluation of over 400 sites, an average of approximately 30 sites per year. See the table for a listing of the number of sites evaluated in each county.

There are few specific regulations for the geohydrologic siting of a sanitary landfill, as opposed to very specific siting requirements for a hazardous waste landfill. Also, there is no strict methodology for evaluating a proposed sanitary landfill, such as the number of test borings per acre. This is because each site is evaluated individually and what may be necessary or appropriate differs from site to site.

Site evaluations are made by one of three methods. They are: 1) review of a site report done by a consultant employed by the site owner/operator; 2) a field investigation directed by a Bureau staff geologist using private drilling equipment provided by the site owner/operator and file information; or 3) the use of Bureau staff, equipment, and file data to conduct the investigation. The Bureau operates a Failing 1500 and a Petti 200 drilling rig that are utilized in these investigations. There is a charge of $500 per day for the use of the Bureau's drilling equipment, which can only be used when investigating a site for a city, county, or other governmental entity.

The majority of these investigations are done on proposed waste disposal sites, primarily sanitary landfills. Several existing sites have been studied in order to document what effect waste disposal has had on ground - water quality in the vicinity.

When the Bureau directs or conducts an investigation of a proposed sanitary landfill site, a staff member generally makes a reconnaissance visit to the site before any drilling begins. This allows the geologist in charge to check considerations such as site access, availability of water for use as drilling fluid, to verify the location of the site, and to explain to the owner/operator what will be involved in the investigation.

After the initial site visit, a review of the existing information on or near the site is made. This includes publications by the Bureau of Geology, publications of other state and federal agencies, and file data stored by the Bureau and other state and federal agencies. Some sites can be eliminated or approved at this stage of the investigation. For example, a proposed site located in a 100-year flood zone would probably be eliminated at this stage. On the other hand, a site located in an area where the geohydrologic conditions are well understood from previous studies, such as most locations in the Selma Chalk, could be recommended for permitting at this time. In some cases, a site might be recommended for permitting by a study of outcrops in the area.

If there is insufficient information to make a recommendation, plans are made to proceed with a field investigation. If the test hole drilling is to be done by a private contractor, the staff member in charge consults with the contractor concerning the number of holes to be drilled, their location, sampling intervals, type of samples to be collected, what type of equipment will be necessary, the location and type of any piezometers to be installed, and when the work will be done. If the field investigation is to be made using the Bureau's equipment and staff, then similar plans are made in-house. The owner/operator is usually consulted before any field investigations are begun to avoid conflicts.

During the field investigation, test borings are made to assess shallow geohydrologic conditions beneath the site. Samples are usually collected and described on 10-foot intervals and retained in the Bureau's sample library. When appropriate, water levels are measured and recorded in augered holes or piezometers installed in holes drilled with wash boring techniques. After the field operations are complete, the information is used to evaluate the geohydrologic conditions and a recommendation is made in writing as to the staff's opinion of the geohydrologic suitability of the site for waste disposal.

In the case of a proposed hazardous waste disposal site, it is the responsibility of the owner/operator to provide the information requested by the Bureau. This would usually include, but not be limited to, in-situ and laboratory permeability tests, cation exchange capacity, total thickness of the confining unit, flow characteristics of the confining unit, computer modeling of the probable paths that leachates escaping the disposal cell would take, and the estimated time before they reach a usable aquifer. Although no hazardous waste landfills have been permitted to date, preliminary work has been done on several proposed sites and one permit application has been filed with the Mississippi Department of Natural Resources by Chemical Waste Management, Inc. This application was withdrawn when the Mississippi Legislature placed a moratorium on the permitting of hazardous waste landfill sites until 1990. The moratorium corresponds with the date by which the U.S. Environmental Protection Agency is to issue a list of chemicals that cannot be placed for disposal in any landill facility.

The Bureau intends to continue its evaluations of proposed and existing waste disposal sites both for government and private facilities. Inquiries concerning waste disposal siting from both the public and private sector are invited.

COUNTY	NO. OF SITES
ADAMS	5
ALCORN	3
AMITE	2
ATTALA	6
BENTON	1
BOLIVAR	3
CALHOUN	2
CARROLL	4
CHICKASAW	2
CHOCTAW	2
CLAIBORNE	11
CLARKE	2
CLAY	3
COAHOMA	6
COPIAH	7
COVINGTON	2
DESOTO	3
FORREST	10
FRANKLIN	9
GEORGE	3
GREENE	2
GRENADA	4
HANCOCK	13
HARRISON	16
HINDS	6
HOLMES	8
HUMPHREYS	2
ISSAQUENA	0
ITAWAMBA	4
JACKSON	12
JASPER	5
JEFFERSON	1
JEFFERSON DAVIS	2
JONES	9
KEMPER	3
LAFAYETTE	4
LAMAR	6
LAUDERDALE	8
LAWRENCE	3
LEAKE	3
LEE	1
LEFLORE	3
LINCOLN	1
LOWNDES	7
MADISON	6
MARION	7
MARSHALL	5
MONROE	1
MONTGOMERY	3
NESHOBA	5
NEWTON	4
NOXUBEE	2
OKTIBBEHA	1
PANOLA	7
PEARL RIVER	7
PERRY	5
PIKE	37
PONTOTOC	0
PRENTISS	5
QUITMAN	9
RANKIN	10
SCOTT	4
SHARKEY	1
SIMPSON	14
SMITH	0
STONE	2
SUNFLOWER	11
TALLAHATCHIE	2
TATE	8
TIPPAH	1
TISHOMINGO	1
TUNICA	0
UNION	2
WALTHALL	0
WARREN	6
WASHINGTON	24
WAYNE	2
WEBSTER	1
WILKINSON	4
WINSTON	2
YALOBUSHA	5
YAZOO	4
TOTAL:	417

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86-2F Biostratigraphy and Palaeoecology of Carboniferous Ostracodes in the Black Warrior Basin; Chris P. Dewey; October, 1986; 75 pgs., $5.00.
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Westgarth Forster
1821

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